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Special Issue: Inspired by Silicon Valley: A Cheap Copy or a Master Piece?

Editors: Ludmila Striukova, Management Science & Innovation, University College
London;

Thierry Rayna, ESG Management School in Paris

Clusters, Technological Districts and Smart Specialisation: an Empirical Analysis of Policy Implementation Challenges

Key Words: Clusters, Technology Districts, Innovation Policy, Smart Specialisation.

Abstract

Recent debate on industrial policy has shifted toward innovation-related issues and economic geography. The conceptual strength and practical implementation of some of these approaches is of concern, particularly the strategic approach termed 'smart specialisation' and its focus on prioritising economic activities with greater potential for growth by relying on processes of 'entrepreneurial discovery'. The cases of Lower Austria, Lithuania and Saskatchewan reveal a wide variety of developmental pathways and associated structures, suggesting that innovation systems should not strive toward a single shape or format of innovation cluster. Mechanisms for identifying a region's technological and knowledge strengths are identified, as well as the existing or possible access points to the market available to a region.

1. Introduction: Emerging Challenges Facing Regional Development

Policies to stimulate growth at the regional level have been adopted by many countries, with a particular focus on investments in science, technology and innovation (STI) and human capital (Lundvall and Borras 2005, Niosi 2010). These regional policies are increasingly seen as a key tool to plan a way out of the current recession (Barca 2009, OECD 2011). Theoretical and empirical work has profoundly affected the way in which policy-makers conceive of innovation triggering economic growth and the regional impacts of agglomeration economies (McCann and Ortega 2013b). In both neo-classical and heterodox economics, economic growth is derived from the potential for investments in innovation to create structural change, notwithstanding the high level of uncertainty normally associated with them. Whether or not this growth eventually materialises depends on the characteristic of the innovation environment. Innovation and growth are linked by the emergence and co-evolution overtime of the multi-agent structures and functions that shape and define complex innovation systems (Martin and Sunley 2007, Saviotti 2011), which makes innovation itself the outcome of system dynamics.

By the end of the 1990s, some regions and urban areas were acknowledged as consistently more innovative than others. North-American high-tech regions were growing faster than most of their competitors (esp. within the EU), generating larger new firms in a shorter amount of time (Audretsch and Thurik 2004). Investments in intangible assets such as R&D, product design, marketing, human capital and organizational development were seen as sources of an innovation potential that advanced economies could translate into growth (Corrado *et al.*, 2009) thanks to their superior entrepreneurial capacity (Acs 2006). Silicon Valley has been identified as the quintessential locus of innovative activity that out-performed its global competitors (Saxenian 1996; Bresnahan and Gambardella 2004). Many regions tried to emulate, or even duplicate, Silicon Valley through policies attempting to reconstruct the reputed key factors of success in Silicon Valley. Many such efforts were unsuccessful; they missed the important and highly complex learning processes that occurred in Silicon Valley's development that generated intangible benefits for local entrepreneurs (Bresnahan and Gambardella 2004; Castells and Hall 2014). The socio-economic networks that evolve in clusters over time cannot be instantly

created alongside the construction of a technology park or development of a venture capital fund (Moore and Davis, 2004).

More successful approaches focus on a region's strengths and resources and local entrepreneurial capacity. In line with this thinking, the concept of smart specialisation (SmSp) emerged from the proceedings of the European Union's (EU) "Knowledge for Growth" expert group (2009), and is conceptually related to work by Hausmann and Rodrik (2003), Aghion *et al.* (2009), Boschma and Frenken (2011). The SmSp literature concentrates on regionally different abilities to absorb, disseminate and exploit general purpose technology (GPT) – such as information and communications technologies (ICTs) and biotechnologies – and to foster innovative applications of GPTs across the wider economy (McCann and Ortega 2013a). According to proponents of the SmSp approach, all regions, whether they are advanced or are catching-up, have a real chance to improve their competitive position. They must exploit GPT to promote innovation and enhance productivity according to the region's unique needs and economic strengths (Aghion *et al.* 2009), increase their own absorptive capacity, and remove inter-regional blockages to knowledge flows. The SmSp approach suggests that policymakers should make selective choices vis-à-vis investments in science and technology, in areas where entrepreneurial processes have the higher probability of stimulating cumulative effects (i.e. agglomeration economies).

The concept of SmSp has grown in relevance in policy circles and the European Commission has adopted it as a necessary condition to access Structural Funds (2014-2020) for Research & Innovation, as part of the Regional and Cohesion Policy's contribution to the Europe 2020 jobs and growth agenda. It is, therefore, important to explore some of the problems associated with the SmSp logic and its implementation by considering two strategic policy instruments: cluster and technological districts policy. Clusters are described as localized production systems that are geographically concentrated with a critical mass of economic actors, specialised in a field of either common or complementary activities, developing reciprocal links of both a market and non-market nature, and collectively contributing to making the local economy more competitive and/or innovative (Porter 1998, Martin and Sunley 2003). Cluster theory is related to the theory of technological districts and innovative milieus, though the latter two theories add more emphasis on technological change and the dynamic nature of the ecosystems within which local actors are embedded; their general focus is on the emergence of technological districts and the role of idiosyncratic institutional co-evolution, path-dependency, networking, collective learning, and increasing returns spurred by investments in technology (Nelson 1993; Simmie 2005).

Basing policy on SmSp requires understanding and being able to solve problems related to system dynamics, such as the risk of excessive specialisation, communication problems and cognitive distance between different agents and the entrepreneurial capacity particularly in catching-up regions. We examine three case studies – Lower Austria, Lithuania and Saskatchewan – which cover economies at different stages of development and have recently experienced structural change, with a view to learn lessons as to how to deal with the aforementioned issues. While highlighting the problems mentioned, these economies also show how a region's technological strengths, its skill and resource endowments, and markets can be incorporated into effective innovation strategy.

2. On Smart Specialisation, Regions and STI Policy

For reasons of history and path-dependency, regions vary in terms of their comparative advantages but also in terms of their evolutionary pathways. For regional administrations to exploit the SmSp logic, they must first undertake a scrupulous self-assessment of the region's knowledge base, technological capabilities and assets, and networks through which knowledge is transferred. This mirrors the argument that regional innovation policy should primarily aim at building institutional capacity, improving accessibility to goods, services and information in the

region, and promoting innovation and entrepreneurship (Cooke *et al.* 2011; Asheim *et al.*, 2011). Thus, according to OECD (2011) a *smart policy mix* for regional innovation must include four key elements: (i) a strategic framework to promote innovation; (ii) policies that rely on relevant factors/capabilities situated within the region; (iii) an effective multi-level governance system to execute the plan; and (iv) established routines for policy learning that draw on in-depth understanding of local specificities and changes due to policy action.

SmSp also calls for a region to exploit convergence with knowledge and technology developed elsewhere and get access to larger extra-regional markets; clusters or technological districts should also be efficiently linked to extra-regional networks and global value chains (Lucas *et al.* 2009; Benneworth and Dassen 2011). A region's ability to take full advantage of the available knowledge pool depends on its entrepreneurial capacity to identify and exploit new combinations between the emerging features of a GPT and the region's existing knowledge endowment (Aghion *et al.* 2009), but at the same time access knowledge developed elsewhere to avoid STI investments across technology/research fields (such as biotechnology, ICTs, and nanotechnology) that lead to unproductive duplication of efforts.

2.1 SmSp Implementation-related Challenges

Some authors opine that the 'narrow targeting of firms, industries and technology' (Niosi, 2010; p. 61) based on the diffusion of a GPT and the development of broader applications around it, as propounded by current proponents of SmSp, may actually stifle the knowledge variety that is crucial for knowledge diffusion and, ultimately, regional growth. Lock-in onto obsolete trajectories may affect entire sub-structures of a regional system; industrial revival would require investments in science and technology domains that are unrelated with the current knowledge base (Frenken *et al.* 2007; Saviotti and Frenken, 2008). Policy practices that systematically help avoid these kinds of risks need to be identified and implemented.

A second problem relates to the central role played by entrepreneurial capacity in SmSp. To Foray *et al.* (2011) the role of the public sector is to supply incentives and infrastructure to entrepreneurs who develop areas of specialisation and GPT exploitation. Since the innovative and entrepreneurial functions within a local system (or even between different local systems, when synergies are can be exploited) tend to remain separated and be undertaken by different sets of agents (Audretsch and Keilbach 2004; Cooke *et al.* 2011), the SmSp approach assumes that communication channels are available to link them effectively, which may not be the case. Therefore, the question is *whether* communication issues can be addressed by effective policy-making.

At a more rudimentary level, SmSp problematically assumes the presence of entrepreneurially-minded actors, with the skills to identify and exploit these opportunities (Mastroeni *et al.* 2013). Successful regions most amenable to specialisation processes already tend to be successful at exploiting their knowledge assets. In contrast, lagging regions tend to lack the pre-conditions for entrepreneurial success – especially absorptive capacity, skills, and venture capital (Oughton *et al.* 2002). The assumptions that (a) the local entrepreneurial capacity exists and (b) entrepreneurs can single-handedly discover available opportunities can be challenged. One must therefore inquire *whether* and *how* policies can address local idiosyncrasies and, in particular, the lack of entrepreneurial capacity, to spur the emergence of new industries, clusters or technological districts (Avnimelech and Teubal 2006).

Innovation is normally the result of interactions between entrepreneurs and the science base, innovators and users, regional actors and external actors (Cooke 2001; Lundvall and Borrás 2005; Asheim *et al.* 2011). Such complexity leads to high levels of uncertainty in terms of technical, economic and social outcomes regarding an activity's possible success. The final question is *whether* and *how* systemic elements of learning can be strengthened to enable the necessary instrumental routines and trust relationships to be built between stakeholders. For

instance, because SmSp aims to create new areas of economic activity and alter the regional status quo, policy design must allow for a range of interested parties to participate; groups threatened by potential changes may attempt to block SmSp efforts if they are not positively involved in the SmSp process (McCann and Ortega-Argiles, 2013a).

3. Cluster/Technological Districts & Policies

Regional development and innovation policies should be informed by, and tailored to, local circumstances (Asheim *et al.* 2011; Borrás and Edquist 2013), and as the above discussion suggests, clusters and technological districts are seen as key concepts for the delivery of effective SmSp (OECD 2012a). Traditional cluster policies normally have a *direct* emphasis on facilitating the private sector by creating a more cooperative environment with fewer transaction costs, better infrastructure, and easier access to global value chains and markets (Storper, 1997). On the other hand, policies that aim at the emergence of technological districts - perhaps by concentrating public-private efforts in a specific technological domain via the setting up of a technopole (Castells and Hall 2014; Komninos 2012) - are usually more focused on the learning of the new techno-scientific competences that could lead to structural change. While being *systemic*, they are normally distinguished from clusters by their emphasis on public-private partnerships for co-investments in R&D, and the creation of global/local networks for the sharing/co-exploitation of existing knowledge.

Resilient clusters/districts (Hudson 2010) attract new firms and other organisations, R&D budgets, and skilled people. Supporting institutions are correspondingly tuned to the need of the local system – networks appear and agglomeration economies benefit local agents. As the localised system grows, critical mass is achieved through incremental change. Clusters/districts are, however, increasingly exposed to global competition and can face decline because their local technological and industrial capabilities become either obsolete or the relevant markets are saturated (Saviotti and Frenken 2008; Niosi 2010). For this reason, many regional/national administrations support local firms and entrepreneurs to innovate and find new forms of industrial specialisation, or help the system transform its-self via the absorption or association with of new competences and agents. These idiosyncratic processes add variety to a region's knowledge- and industrial-base, creating the pre-conditions for the exploitation of new opportunities (Martin and Sunley 2011).

In both cases, entrepreneurial capacity may need to be developed or regenerated, new competences created through long-term investments in sciences, technology and education, and old institutions revamped and/or new institutions set up in line with the new strategy. In these respects, while networking platforms and interaction among the clusters members is vital, external connections through global networks and value-chains should not be neglected (Lucas *et al.* 2009; Beltramello *et al.*, 2011). SmSp does not necessarily need to be spatially bound to a particular region. Especially when it comes to Europe-wide policy making, regions can share and pool resources, skills and knowledge in order to increase their economies of scale. It follows that supporting clusters/technological districts emergence and development requires the introduction of a complex policy mix requires proper coordination and engagement among different level of government, policy actors, and stakeholders (Lyll 2007; Rosiello *et al.* 2013; Borrás and Edquist 2013) In many places, policy-makers tasked with the design and implementation of SmSp via cluster/district policies thus also face the strategic challenges and research questions discussed in section 2.2 (OECD 2012b). As a result, they constitute the foci of this paper.

4. Methodology

In the next section we examine how implementation problems and strategic challenges have been dealt with in Lower Austria, Lithuania and Saskatchewan. These case studies present

innovation policy frameworks aimed at triggering structural transformation of the local industrial base through the exploitation of their latent technological competences, alongside investments to expand the range of such competences, entailing synergies between private and public sectors. The respective systems of governance appear to be extremely different; it is therefore interesting to examine the varying processes and mechanisms of activity coordination and dispute resolution among the different players involved.

There are thousands of potential case studies one could choose (Ryan and Phillips 2004). We have selected three regions that have examined for other reasons to interrogate through the Sm/Sp lense. The cases reflect the core-periphery relationships that exist in Europe and North America. Two cases involve peripheral regions, one with a transitional economy (Lithuania) and one with a stable socio-economic context (Saskatchewan), and the third (Lower Austria) is adjacent to the core of the industrial heartland of Europe. The three cases offers insights into the range of potential strategies regions embedded in in advanced industrial economies could employ.

Lithuania is a green-field site for innovation policy facing many challenges, including limited entrepreneurial culture and inexperienced investors. Nevertheless, the Lithuanian government released an ambitious innovation strategy in 2010 which states that by 2015 it would become an innovative-service hub for Northern Europe and an innovation hub by 2020, within which a number of key specialisations have been identified (Government of Lithuania, 2010). The evidence used was collected by Rosiello and Mastroeni, as part of an EC FP 7 to design an effective policy process for intervention to develop their innovation systems, specifically in the field of biotechnology. The Research Council of Lithuania acted as the liaison during data gathering – including semi-structured interviews with local players, policy reports, and data for the local economy.

The Lower Austria case was documented by two of the authors (Mastroeni and Rosiello) as part of the “Smart Specialisation strategies for innovation driven growth” project OECD Working Party on Innovation & Technology Policy (TIP). Lower Austria was one of the European Regions whose advanced innovation policies and specialisation strategies were studied to learn useful lessons in order to develop Research and Innovation strategies for SmSp (S3) for Europe (and beyond). Rosiello worked with policy-makers in Lower Austria to analyse available data and policy reports. Lower Austria has embraced the SmSp policy principle: it utilises sophisticated tools to assess regional assets/capabilities and monitor the progress of the regional strategy, a set of well-defined specialisations, and is capable of effective multi-level governance with extensive participative elements (OECD 2012a). Clusters and technological districts are two key tools for the implementation of the regional innovation strategy.

Saskatchewan is a large, sparsely populated Prairie province in Western Canada that has been going through a major economic transition in the past 20 years, precipitated by a number of new GPTs and a corresponding resource price boom. After the better part of a half-century of declining importance as a peripheral producer of low-value added agricultural, mining and energy products, the application of biotechnology and advanced instrumentation has accelerated innovation and productivity in the core sectors (Phillips and Webb, forthcoming). While most of the basic GPTs were developed elsewhere, various public, private and producer partnerships, anchored on the two universities, have reduced them to practice and adapted them for use in the context of the local industry. This has precipitated a sharp rise in world-first innovations in the agricultural biotechnological, oil and mining sectors. All three orders of government—federal, provincial and municipal—have participated in generating the conditions for this transition. A series of recent quantitative and qualitative assays of the region provide the foundation for this study (Phillips and Khachatourians 2001, Phillips *et al.* 2012).

5. Case studies

5.1. Lithuania

Lithuania is a country of approximately 3.5 million people, with a GDP of US \$42.4 billion (2011 – IMF World Economic Outlook, 2012) and a growth rate of 3.7% in 2012 (Bloomberg, 2013). Lithuania offers a case of government intervention to promote the emergence of a functioning innovation system based on a few key strengths. It features an innovation system with an under-developed entrepreneurial capacity outside of a few pockets of experience (from 1988-1997 the first firms were spun-off from public research institutes, with very little start-up /spin-off activity for the subsequent decade). Until 2008, much of Lithuania's innovation policy has been general and *ad hoc*, but in 2008 a series of policies was introduced to more effectively create technopoles in particular areas of existing scientific strengths.

A White Paper on innovation released by the Ministry of Education and Science in (2002) noted that Lithuania had “provisions for a rapid development of technological progress”, especially key firms in biotechnology, laser production, and IT research potential developed during the Soviet period. According to the White Paper, these industries operated based on fundamental technologies produced in Lithuania, a good level of concentration of science in key cities and many potential combinatory possibilities.

Lithuania's innovation system has evolved from Lithuania's Soviet and post-Soviet history. For example, during the Soviet period, Moscow selected Lithuania as a research centre focusing on biotechnology, establishing the Institute for Biochemistry in 1967, and the Institute for Applied Enzymology in 1975 (later becoming the Institute of Biotechnology in 1990). In the face of financial difficulties resulting from the Soviet Union's collapse and Lithuania's post-Soviet transition, scientists in 1992-94 were allowed to spin-off companies with Institute intellectual property, and fixed capital, leading to the creation of the “big four” firms in the biotech sector (Fermentas, Sicom, Biok, Biocentras). These newly established firms maintained the client relationships the Soviet institute had with foreign organizations (Dickman, 1992). These firms were also able to maintain research/training relationships with the Institute of Biotechnology which in turn maintained its high quality foreign collaboration and research (NSF, 1997). The laser industry in Lithuania mirrors the biotechnology industry in that all laser firms have their roots in the Soviet-established Institute of Physics (est. 1970) and Vilnius University research. One company, Eksma, was started in 1983 to represent Soviet laser products to eastern markets and in 1987 to Western European markets (privatized in 1990), with Ekspla being spun-off in 1992 as an additional private company. Standa was started in 1988, viesos Konversija in 1994, and Optida in 1997 (www.zef.lt). The industry has been reorganized for its high quality research lasers, taking significant market shares in the industry (e.g. half of all picosecond lasers worldwide are Lithuanian, with up to 80% global market share in smaller niche products).

From 1975 to 1990, the scientific capabilities of Lithuania's innovation system were developed by Moscow's fiat; while from 1991 to 2001 entrepreneurial ventures emerged without the same central planning. Since 2002, more pro-active policies have been introduced to promote the co-evolution of science, technology and innovation. The shift in policy was triggered by Lithuania's move to join the European Union, the abovementioned White Paper on innovation, and external analyses of Lithuania's innovation performance by the European Commission and World Bank (Thorn and Morgensen, 2009; Inno-Policy, 2008; CREST, 2007).

5.1.1. A Policy Mix for Innovation System Development

Referring to the cluster life cycle approach mentioned above, Lithuania is in the pre-emergence phase. Policy programmes were put in place to address the capacity of the innovation system, largely geared towards improving infrastructure conditions, skills and business capacities within the Lithuanian economy. The policy programmes consisted of EU Structural Fund Implementation Programme (2004–2006), National Lisbon Reform Programme (2005–2007), and Operational Programme for Economic Growth (2007–2013). Specific interventions were

undertaken in an *ad hoc* manner until 2010. In 2010, an Innovation Strategy was released which was meant to coalesce Lithuanian efforts in building a system of innovation. Some of these programmes and the Strategy itself, however, demonstrate the challenges to innovation policy described in Box 1.

The first challenge lies in the division of powers and rivalry for resources and jurisdiction between the Ministry of Science and Education (in charge of research) and the Ministry of Economics (in charge of innovation). The two ministries complicates coordination, the consequence of which is that ideas or programs that may be useful for overall improvement have not had as wide an impact as hoped. In fact, the national Innovation Strategy released in 2010 is the first real instance of cooperation between the two bodies. Coordination, however, has been problematic at many levels. In 2006, when 24 National Technology Platforms were made up to join public and private sector stakeholders in particular areas of specialization to increase cooperation, some over-specialization and fossilization of research agendas emerged (Target Report 2011).

The challenge of targeting and timing can also be seen in Lithuania's Innovation Strategy (Lithuania, 2010). The Innovation Strategy (launched in 2010) and the Innovation Strategy Implementation Plan (2011) were meant to help Lithuania correct systemic limitations and move beyond its current technological frontiers, making it an innovation hub for Northern Europe by 2020. The problem with these documents is that they did not explain how this would be carried out, instead describing a series of programs with little consideration of overall direction and resource implications.

Targeting has also prevented the main funding program in Lithuania, Invega, to foster growth in the knowledge-based or technological sectors. Founded in 2001, Invega's role is to promote the development of SMEs and facilitate their access to funding (Thorn and Morgensen, 2009). While Invega's programs are open to any sector, their set-up makes it difficult for knowledge-based companies to access them. Invega's main service has been loan guarantees, which require companies to provide collateral based on capital equipment or liquid assets. Because knowledge-based companies tend to have few capital assets, other financing programs geared towards innovation have been launched, including one with European and Baltic partners, but it is too early to evaluate their impact (Ministry of Economy, 2012).

An initiative that is more positively viewed by Lithuanian stakeholders is the Science Valley Scheme. While it was approved in November 2008 and launched in 2009, it has been incorporated as one of the main pillars of the Innovation Strategy. The Valleys' purpose is to consolidate the R&D infrastructure by merging independent research institutes and university institutes and coordinate R&D resources in concentrated geographic areas. As of 2011, five Valleys were created in different areas of technological strength. Research infrastructure was amalgamated from 17 state research institutes, 18 university research institutes and 10 state research "establishments" to 5 state research centres, 6 state research institutes, and 14 university research institutes (from 45 to 25 public research facilities).

Research in the Valleys is meant to take place in "Open Access Centres" where academic and private sector groups would have open and equal access to research infrastructure, implying increased proximity (Intelligentsia, 2010). Key components of the Valley include: business incubator services; technology-transfer services; entrepreneurship development programmes; and joint marketing schemes. This particular aspect of technopole development is hopeful because it addresses identified needs (see Thorn and Morgensen, 2009; CREST, 2007) and focuses resources in broad areas of strength without cutting off new potential pathways for technological development or convergence. In the biotechnology Valley (Santara), for example, relationships established before the Valley's founding are continuing and being used to persuade further networking. Furthermore, private sector leaders whose experience was built

from the immediate post-Soviet firm formation, have accepted the institutional inexperience of the public sector and have been working in conjunction with the public sector to improve aspects of the innovation system, including reinvestment of wealth into new ventures.

Overall, Lithuania sits in the pre-emergence phase of cluster development as many of the components of its innovation system require further development and a critical mass of activity and experience still has to grow. This case, however, also demonstrates the learning process on the part of policymakers and stakeholders involved in innovation that forms a key part of effective technopole building and cluster policy.

5.2. Lower Austria

In line with the EU current SmSp approach, regional innovation policy in Lower Austria emphasises technological and skills diversification, facilitation of cross-sectorial synergies within a framework that prioritises broad themes rather than sectors, and continuous monitoring of the strategy's progress via both qualitative and quantitative indicators.

Lower Austria is one of nine federal provinces in Austria, near Vienna. The provincial capital is Pölsen. The population was 1,66 million with unemployment rate 4,1 % and GDP € 45.4 billion (2010) with export rate 44,9 % in 2011 and R&D expenditures of 635,4 million (1.44% of GDP) in 2010. Lower Austria can rely on Vienna's strong academic infrastructure and it has some important public research organisations, such as parts of the AIT (Austrian Institute of Technology), IASA (International Institute for Applied Systems Analysis), and IST Austria (Institute of Science and Technology Austria). Lower Austria already has a diversified industrial structure with sectors such as mechanical engineering, metal processing, wood, food, chemistry, oil, rubber and plastic (Priedl 2009). Its geographic position favours access to the rapidly growing markets of Central/Eastern Europe.

Nevertheless, SmSp is seen as indispensable to reach critical mass of (public) R&D investments in strategic domains and improve the region's exploitation capacity. Lower Austria adopted an innovation strategy in 1997, with the initial phase shaped around the concept of RIS from 1999 until 2008 and second phase called the Economic Strategy Lower Austria 2015. Both phases targeted thematic priorities including: innovation and technology; qualification; collaboration; internationalisation; start-ups; and ecological/resource efficiency,

Regional coordination and collaboration through the RIS Steering Committee was set up in 1997 and includes representatives from the Regional Government, local companies, clusters, technopoles, and the Chamber of Commerce, alongside members of local academe and research organisations. Lower Austria monitors the progress of its strategy using qualitative survey and quantitative data collection/analysis. It uses the Balanced Scoreboard System (BSC) which monitors the policy implementation and its impact assessment by measuring achievements against regional objectives defined by the Economic Strategy 2015.

5.2.1. A Policy Mix for innovation-driven differentiation

There is strong cooperation among local, regional, national and EU authorities in relation to regional innovation strategy. At local level, various agents are in charge of key aspects of the innovation policy design and implementation: WST3 is responsible of economic strategy and financing, Ecoplus for the support network, the Technology and Innovation Partner (TIP) for a number of services including coaching SMEs and start-ups, patenting support, technology surveys, and other agencies for regional equity capital and guarantees, promotion of foreign investment, and national grants, guarantee, and loans.

Overall, the policy framework aims to build linkages, networks and synergies within and across technological domains, enhance knowledge-related strengths, set up cross-regional coordination activities, support local SMEs, and create proper *pre-conditions* (infrastructure; financial assistance for R&D investments and innovation; and advice and professional support)

for entrepreneurial start-ups in domains that fall within the region's comparative advantages. The regional strategy encompasses three main policies: the Technopoles Programme, the Cluster Lower Austria Programme and the Technology and Innovation Partner (TIP). The Cluster and Technopoles programmes differ substantially. With a broad sectorial focus, the Lower Austrian Clusters are more open in geographic terms, as cluster members need not to be located in Lower Austria. Technopoles aims at the growth of research-intensive areas and uniquely consist of the companies, research and educational organisations situated in or around them. The Lower Austrian Clusters program is significantly smaller than the Technopoles Program and the gross value added yielded by the cluster projects is one-fourth of that of Technopoles projects (Berrer *et al.* 2010).

Technopole Programme:

Technopoles respond to the need for technology- and innovation-driven differentiation; they are supposed to be loci where research organisations, university (education) and business (economy) cooperate in a synergetic manner. Started in 2004, the programme was planned to last until 2013 and aims not only to generate new knowledge domains and strengthen the regional technological potentials, but also to help to translate assets into economic growth. This was to be achieved by supporting applied research carried out by R&D institutions in emerging techno-scientific fields and by making existing problem-solving technological skills directly available to the business sector.

The Technopoles programme has been financed by the regional government, and its implementation is led by the organization Ecoplus. The funds cover services provided by the Technopoles, whereas the cost of the individual projects is financed by different sources, such as Lower Austria itself, ERDF, and the business sector. There are technopoles in medical biotechnology (Krems Technopol, focused on regenerative medicine), agro and environmental biotechnology (Tulln), modern industrial technologies (Wiener Neustadt - focused on materials, sensors, and medical- technology), and a fourth technopol focused on renewable resources is being established in Wieselburg.

The Technopoles have helped rationalize the region's R&D by reducing the number of technology fields from 32 in 2004 to 16 by 2010. The number of researchers increased from 180 to 1007, scientific publications from 343 to 1515 and patents from 5 to 145. Ecoplus in 2010 provided evidence that the establishment of Technopoles triggered structural change within the Lower Austrian industrial system. Above all, knowledge-intensive, industry-oriented services and capabilities with high value-added have developed faster around technopoles than other locations of Lower Austria (Berrer *et al.* 2010).

Quantitative data suggest that the gross added-value effect produced by firms located at the Technopoles Tulln, Krems and Wiener Neustadt is €191 million. Of this, €119 million, has a direct impact on the economy of Lower Austria, whilst around 30% leads to positive impacts abroad and 8% positively affects other Austrian regions (Berrer *et al.* 2010). The direct employment effect at the Technopoles is 1,386 persons in 2009. Combining data from regional business statistics reports together with multiregional input-output analysis, the total employment increase was 2,187 jobs by 2011.

Cluster Programme:

In 2001 the Ecoplus agency started the Cluster Lower Austria Programme. To date, there are five clusters initiatives. The Green Building Cluster focusing on improving the environmental aspects of construction and new and old buildings; the Plastics Cluster, which involves cooperation with Upper Austria and Salzburg, Europe's largest network for plastics technology, and specialises on bio-based plastics, compounding and recycling; the Food Cluster, from

agriculture to processing and food retailing; the Mechatronics Cluster, which involves collaboration between Lower and Upper Austria; and the Logistics Cluster.

The programme promotes innovation through cooperation among local firms, supporting agents and institutions. The cluster program is specifically focused on developing supply connections and collaborative behaviour between business-sector R&D, new centres of competence (such as the Future Building Competence Center for R&D in the field of sustainable building technologies, components and systems) and product certification capabilities, and promoting collective action in relation to marketing and access to global markets. The project funding comes from private sources through memberships and services fees, and public sources through regional and ERDF funds.

Ecoplus defines cooperative projects as projects with at least three partners, and Cooperative projects are the most common type of activities undertaken within the clusters. The five clusters have carried out cooperative projects with a total volume of €42.2 million with public funding of around €13.5 million. In total, cooperative projects make up 81% of the total project volume in the five existing clusters. Roughly 32% of total project volume originates from funding in cooperative projects (Berrer *et al.* 2011).

In total, around 590 companies with roughly 72,000 employees are involved in the Ecoplus Cluster programme. Until 2011, around 300 cooperative projects had been completed. There were a total of 71,983 employees within the five clusters, with a combined turnover of around €23 billion (2011). The cumulated project volume of the five clusters was equal to €52.2 million. Public funds contributed 49% of the total funding. In terms of the estimated impact of such investment, up to 2011 added value had been created for overall effect of €27.3 million. The total employment effect amounted to 624 jobs in person-years and 560 full-time employees. The overwhelming share (71%) of the value added effects had been generated by the Green Building Cluster (Berrer *et al.* 2011).

5.3. Saskatoon and the biotechnology based canola cluster

The Great Plains region of western Canada, with about six million people and 130 million acres (more than 80% of the nation's agricultural lands), has a strong comparative advantage and significant export market share in the production of grains, oilseeds and other field crops. Saskatoon in the north central region of the crop area has a population of about 230,000 and a market area of more than 600,000 people. This city hosts two main clusters - the agri-food complex and mining service, supply and management - which do not interact to any extent. While innovation in mining has lagged at times, the agri-food complex has positioned the city as a niche science-based technopole, with about double the national rate of highly skilled workers and a disproportionate share of the nation's research infrastructure devoted to crops-based research.

The Saskatoon bioscience cluster represents a case of global pipelines accessing local knowledge, and exemplifies an *entrepot*, drawing on global technology and finance, locally assembling new technology and then exporting it to world markets (Phillips 2002). The land-grant style University of Saskatchewan was founded in 1907 – within the Saskatoon city limits. In the mid-1980s the modern cluster began to form as global agro-chemical companies were looking for early candidate crops to genetically modify using newly developed technologies. The prevailing view at the time was that the three easiest and best candidates were carnations, tobacco and canola. Developed by Canada as a low erucic acid and low glucosinolate rapeseed, canola was attractive as it was an edible oilseed with a relatively large crop area, sophisticated domestic supply chain, and global market share dominated by Canada. Given its earlier experience with canola, the natural place to locate research on new canola varieties and genetically modified lines was Saskatoon. Public scientists and a few leaders in commodity funding groups worked closely with multinational companies to realize this potential.

Within a few short years, a technopole emerged around canola, with private and public actors cooperating and making extensive use of external knowledge inputs to develop the scientific and technical base for crop innovation. Actors investigating using biotechnology to modify canola included the two federal laboratories, faculty at the University of Saskatchewan, multinational companies, and the leading local farmer-owned cooperative. Cooperation was supported through a wide array of public and collective organizations that emerged in the late 1980s and early 1990s to knit together competitive programs into a regional specialization. Federal policy and initiatives were vital. For example the federal government moved to adopt plant variety protection, while federal court rulings effectively extending private intellectual property ownership to new varieties (Malla *et al.* 2004).

5.3.1. Effective multi-stakeholder governance in support of cluster emergence

The federal government made a strategic decision to consolidate its research effort and align it more with private investments. The National Research Council, Canada's largest research organization, recruited one of the world's top biotechnologists to the city and repurposed the local facility as the Plant Biotechnology Institute, offering 'platform' research programs to solve some of the technical issues in effective plant transformation. Meanwhile, Agriculture Canada, which in the past was one of the leading breeders of canola varieties, made a series of changes that eventually led to Saskatoon becoming the oilseeds research centre for Canada, with extensive 'fee-for-service' custom breeding and heavy use of 'matching' to leverage private investment; correspondingly, Agriculture Canada no longer produced their own varieties in competition to industry. Expertise was further concentrated as Monsanto, AgrEvo and Dow relocated research staff to access the capacity in the local public institutions, and crop developers found ways to partner and engage in this hub of activity, either through research collaboration or through partnerships to manage breeding and field trials.

Saskatoon's biotechnology cluster's inception has interesting and idiosyncratic dynamics. First, despite being local, provincial and municipal governments played a minor role, and the university did little more than play host to the activity and produce highly skilled researchers who staffed the public and private research efforts. Federal actions, discussed above, were more important, and included legislation that enabled commodity groups, the most aggressive adopters, to institute check-offs for research and market development. Second, while with other cases of innovation individual entrepreneurs are often critical leaders of clusters, in this case leadership came from a number of public-private-producer partnerships, which in addition to explicit research efforts, undertook an array of foresighting efforts with partners and stakeholders and participated in broader public engagement to advance their collective agenda (Smyth *et al.* 2002). Third, in contrast with other product categories, producers aggregated their efforts into an industrial association - the Canola Council of Canada (CCC) - which coordinated their research efforts and leveraged both government and private funds, including funds from multinational biotechnology companies, oilseed crushers and processors and the wholesale trade (Gray *et al.* 2006).

Once the cluster had emerged, the province of Saskatchewan, in collaboration with emerging bioscience firms, developed a series of not-for-profit industry organizations to deliver business development and venture financing to the sector; these efforts have now consolidated into Ag West Bio Inc., a leading coordinator for the cluster. This densely packed and highly coordinated community was highly influential with the Canadian regulators, who efficiently and effectively evaluated and approved a wide range of new GM canola varieties for release, and then worked with the developers and CCC to assure foreign markets of the safety and efficacy of the new technology. The end result was that by the early 2000s, almost all of the Canadian acreage was planted to novel varieties in three competing platforms (Monsanto's Roundup Ready, AgrEvo/Bayer's LibertyLink and DuPont Pioneer Clearfield). In response to the improved

profitability of canola relative to other crops in the rotation, canola acreage has almost doubled since these new traits were first introduced in 1995.

Between 1985 and 2000, joint investment by industry and government of more than C\$200M globally (much of it in or linked to Saskatoon) produced five new traits expressed in more than 60 varieties that were generating more than C\$240M benefits annually in 2000 (Phillips 2003). Beginning in the early 2000s, a realization that the regional biosciences specialization could not be sustained solely with a mature canola-based cluster triggered programs to renew and broaden expertise. Efforts to extend the canola program into second generation (quality enhanced traits, such as specialty and industrial oils) and third generation (plant made pharmaceuticals) crops met push-back in key foreign markets nervous about GM foods. Many multinationals decreased their local research effort, precipitating concerted effort by the leading industry associations and commodity groups to diversify the bioscience base.

The local bioscience community's involvement in creating Genome Canada, a federal special operating agency, triggered almost C\$2 billion in genomics and proteomics research in Canada over the past 12 years. A disproportionate share of the funding flowed to Saskatoon (almost all of it agriculturally focused), leading to the creation in Saskatoon in 2005 of Genome Prairie, a project development and management firm linked to Genome Canada. Meanwhile, almost all of the commodity groups have begun to invest heavily in new crop development. Coincidentally, the federal government reconfigured PBI in 2012, converting the institute into a 'wheat improvement flagship' engaged in a C\$100 million multi-year program. The university, with strong support from the province and city administration, has also engaged more aggressively, sponsoring and hosting the development and operation of key infrastructure (e.g. the Plant Phytotron and the Canadian Light Source Synchrotron), key research facilities (e.g. the Crop Development Centre, the Feeds Innovation Institute and the Vaccine and Infectious Diseases Organization) and new research programs (e.g. the C\$50M Global Institute for Food Security and Canada Excellence Research Chairs in water security and 'one health', each worth C\$20M).

In contrast to the two European regions, the leadership of the technopoles in Saskatchewan has usually been less formal, with different public actors, key entrepreneurs, various civic leaders and some university officials and scholars taking the lead at various times. Furthermore, in contrast to the two European cases, the Saskatchewan technopoles are far less formalized, with little in the way of strategic branding and a rather porous boundary, which allows actors to both defect and enter at will. One striking similarity is that the Saskatchewan technopoles seldom see themselves as independent of the larger economy—some key entrepreneurs, much of the capital and most of the innovative technologies are explicitly imported to make the system function.

6. Conclusion/Discussion

The three case studies illustrate economies at different stages of development. The different staging of the cases leads to the policy frameworks differing quite substantially. Lithuania is an embryonic system with a techno-scientific base in specific domains created during the Soviet era, some entrepreneurial successes, and innovation system structures only recently created or restructured. Lower Austria, in contrast has a sophisticated system of governance, a strong and diversified techno-scientific and industrial base, market opportunities in the proximate markets of Eastern Europe, but little critical mass in industrial R&D. Finally, Saskatoon illustrates a mature case where actors have identified and exploited a market opportunity via a coalescence of local knowledge involving a wide variety of cooperating stakeholders. The three cases show the evolution, ebb and flow of cluster and/or technological district development, and the need to adjust policy according to market changes, system needs and failures and opportunities. The

overall implication for SmSp-based innovation policy is the need for in-depth analysis and evaluation of local idiosyncrasies, that is, techno-scientific and industrial strengths, systems of governance, endowments and needs, and periodic re-assessment to monitor system changes and needs.

The case studies, summarized in Table 1 below, illustrate specific challenges facing regional innovation policy (including supporting local clusters/districts), and how SmSp could be structured in its execution to overcome these challenges, moving beyond the initial conceptualisation by Foray *et al.* (2011). To begin with, we note that the efforts to support formation of clusters and technological districts in different places often have different formats or configurations. Different formats emerge from the reality that cluster policy tends to build on already existing capacities, stimulating networking and cooperation to strengthen critical mass around R&D and private sector entrepreneurial efforts. For instance, the case of Lower Austria illustrates that technopoles can be created to generate a techno-scientific baseline to move forward with innovation – for that reason they can become an important source of knowledge spill-overs and economic development, and help the local economy diversify into new industrial domains.

Depending on the local context, however, this can only be achieved by also creating the social, institutional, communication, and physical structures that constitute the pre-condition for synergy and co-investment. This is crucial as spill-overs effects at close geographic proximity (Kolympiris and Kalaitzandonakes 2013) have a stronger bearing on technical districts emergence than it the case with already established clusters. The Lithuanian case shows how technological districts may face over-specialisation in that it can cut-off new areas of technological development, something which was a concern under Lithuania's National Technology Platforms but will hopefully be avoided with the Valley Programme. The efforts in Saskatoon leading to its focus on canola also eventually led to a need to expand research applications in order to remain competitive. In the three cases we see that the organisational arrangements, type of activities invested in, and players involved vary because of the different techno-scientific and industrial bases. The cases also highlight common advantages: diversification but also rationalisation of the R&D portfolio with more focused efforts around activities with a greater potential for innovation and structural change; creation of greater critical R&D mass; and general science and technology themes identified by policy-makers, whereas the selection of commercial exploitation does not seem to involve the selection of pre-determined domains of specialisation.

Secondly, the case studies show that entrepreneurial capacity is not always represented as a straightforward privately-driven phenomenon, but rather that entrepreneurial opportunities may be identified and taken by a variety of stakeholders. This also impacts the shape and form of clusters and technological districts; the cases show the possible breadth of structure and development pathways, the constants being instead in the effective identification of a region's technological strengths, skill and resource endowments, and existing or possible access points to the market. Innovation policy involves therefore acknowledging and working with this variety of execution, while noting the constants of strategic planning and regional evaluation.

Regarding the first point, the Saskatoon case study offers an example of selecting and sorting, posited to be entrepreneurial discovery, that is not (uniquely) driven by the private sector. In this sense, it constitutes a different narrative than presented by authors such as Hausmann and Rodrik (2003). In the case of Saskatoon, entrepreneurial leadership was exercised by actors with entrepreneurial insight who are not necessarily in the private sector, and who moved the innovation agenda forward individually as well as in partnership with other public and private (regional and multi-national) stakeholders. Lower Austria, with its effort to stimulate cooperative/synergetic behaviour - with both cluster and technopole initiatives – seems to

exhibit similar diversity of leadership. The normative implication is that in places where private entrepreneurial capacity is lacking or hesitant, which could have negative implications for the domestic system to develop further, policies that aim at stimulating the undertaking of new entrepreneurial activities can be complemented by efforts to coalesce knowledge and create public-private partnerships to exploit emerging opportunities.

Thirdly, regarding the relative importance of local versus non-local factors for cluster/district emergence, the three systems displayed openness to external connections and markets. In Saskatoon, canola was developed as a response to the recognition of a global market opportunity. In Lower Austria, cluster initiatives involve partners outside the region and access to growing markets of Eastern Europe represent a key priority for the overall strategy. In Lithuania, extant entrepreneurial successes are based on access to global markets and capital inflows from Europe and North America are deeply shaping the emergence of local districts. In conclusion, both local and non-local dynamics operate in each of these clusters/districts and they are in no way reciprocally exclusive.

Finally, the cases demonstrate the importance of multi-stakeholder involvement and coordination around technopole and cluster initiatives—progress and success comes from different players sharing a clear strategic intent. Lower Austria's federal institutions, regional steering committee and local strategy were co-evolved. Saskatoon's close-knit community of scientists, entrepreneurs and policy leaders have put together federal resources, provincial and regional assets, local farmers and multinational firms to deliver first-in-world crop technology innovations. In Lithuania, where conflict between the Ministry of the Economy and Ministry of Education created an initial barrier to effective innovation policy, the system of innovation developed coordination through informal networks that allowed private and research sector actors to work through their conflict.

*** INSERT TABLE 1 HERE ***

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TABLE 1

	Lithuania	L. Austria	Saskatoon
System and industrial status/maturity	An embryonic system of innovation, with some maturity in the areas of industrial and enzyme production, and laser/photonics from Soviet origin.	A mature, diverse, industrial system in traditional industries, looking to introduce R&D to create an innovation system that can renew the sectors and create new areas in sustainability.	A mature industrial system based on R&D with a particular specialisation – resistance to 2 nd and 3 rd gen in specialisation spurring efforts to diversify
Entrepreneurial capacity	Nascent, though with a core of experience stemming from the few firms founded in the immediate post-Soviet period	Variable – established industry with experienced managers, though with entrepreneurialism emerging out of new and established enterprises in the movement to rejuvenate or find new market sectors	Extra regional – in the sense that most of the initiative was federal and provincial, as well as coordinated by different organizations.
Local resources/capacity	Limited to specific niche strengths, yet only recently concentrated in terms of R&D capacity into specialised Valleys. Limited investment capital and experience.	Breadth of industrial resources, and easy access to external R&D systems in nearby capital.	Extreme specialized resources at federal and provincial level, and high quality R&D in the specific sector. Strong specialisation
Network Capacity	Initially limited public sector coordination due to resource competition Good informal private sector network amongst anchor firms Growing R&D networks, starting from niche sectors and growing from EC initiatives Internal networks potentially expanded through Valley Scheme	Strong public and private sector networks in industry, establishing networks in R&D.	Strong public-private networks, though in a specialised area.
Strategy Summary:			
Lithuania:			
Lithuania's innovation strategy shows positive elements tailored to the strength and requirements			

of the region in some things, with other elements too focused on general European indicators of innovation and a “wish-list” of achievement that may or may not be possible.

The former is reflected in the Valley Scheme that is simultaneously consolidating the strengths in the niche areas, while creating an atmosphere to facilitate knowledge exchange that will possibly lead to a greater diversity of niche markets. Services are being offered such as business advice and seed funding to facilitate nascent entrepreneurialism.

The efforts to finance SMEs and other programs outside the Valley system seem ad hoc, overly general and not well-funded enough to alter the system in necessary ways.

L. Austria:

The combined cluster and tech platform strategy is clearly geared towards L. Austria’s peculiar strengths a well-developed industrial structure; and the associated weaknesses, the need to regenerate the industry as the key industries are in “old” traditional sectors.

The push for innovation in sustainability and niche sectors in areas that combined knowledge or offshoots stemming from such individual experience means that L. Austria is tapping into its unique knowledge capital, while still drawing from national and international knowledge networks.

Saskatoon:

Saskatoon’s innovation strategy demonstrates a leveraging of the successful public-private networks and “entrepreneurial” leadership by the public sector to both renew and expand the agro-bio sector from its canola base to other related technologies through Genome Canada funding and large science initiatives. This is responsive both in terms of its strengths, but also the barriers encountered with stakeholders resisting for 2nd or 3rd gen canola developments.

The question that this strategy raises, however, is how transferable are the R&D investments to new markets or to the rapidly adapting private sector or end-users?